# DESIGN OF NEW NANOCOATINGS BASED ON HARD ALLOY

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The possibility of creating high-entropic nitride, carbide, boride and oxide coatings on a solid T12A alloy was researched, and the possibility of applying nitrides, carbides, borides and oxides of hafnium, zirconnium, molybdenum, tungsten, yttrium and nickel was considered. For that, on the basis of the joint problem of thermal conductivity and thermoelasticity, the volume of grain and the depth of occurrence for the elements considered, as well as nitrogen, carbon, boron and oxygen were determined. For nitrogen, the dependence of the grain volume of the maximum and minimum depth of occurrence was found. It was determined that the volume for low energies of the order of 200 eV corresponds to the nanograins, whereas at higher energies it exceeds them, the depth of occurrence of the volume in the first case lies in the range $8.6 \cdot 10^{-10} \ldots 3.9 \cdot 10^{-9}$ m – the minimum and $2.7 \cdot 10^{-9} \ldots 6.8 \cdot 10^{-9}$ m – the maximum.

For the case of the action of boron ions, the grain size increases: it lies in the range of $4.4 \cdot 10^{-9} \ldots 1.364 \cdot 10^{-7}$ m. So, in the last case we deal with submicrograin, the depth of its occurrence: the minimum lies in the range of $1.2 \cdot 10^{-9} \ldots 9.29 \cdot 10^{-8}$ m, and the maximum – $2.9 \cdot 10^{-9} \ldots 1.07 \cdot 10^{-7}$ m. In this case, the depths of occurrence exceed all the previous ones, so well as the grain size.

Turning to the zirconium ($Zr^{+}$) dependencies, we find that NS is realized for practically all the energies studied. Moreover at 200 eV the depths of occurrence are: the minimum – $0 \ldots 6.3 \cdot 10^{-10}$ m; the maximum $3.34 \cdot 10^{-9} \ldots 5.43 \cdot 10^{-9}$ m. At 2000 eV the minimum – $6.37 \cdot 10^{-10} \ldots 5.37 \cdot 10^{-9}$ m; Maximum – $5.4 \cdot 10^{-9} \ldots 1.25 \cdot 10^{-8}$ m. For 20 keV, the minimum depth of occurrence is $4.6 \cdot 10^{-9} \ldots 2.48 \cdot 10^{-8}$ m; the maximum is $1.54 \cdot 10^{-8} \ldots 3.52 \cdot 10^{-8}$ m.

From a comparison of the depths of NS for hafnium and zirconium ions with the penetration of nitrogen ions, we see that many nitrogen energies cannot be used, because the depth of their penetration is greater, and in many of the regimes nitrides, carbides, borides and oxides will not be formed, but there will be a rather large amount of intermetallides that have small physical and mechanical characteristics, so consequently there will be zones in the material with reduced properties, that will not provide the appearance of highly entropic nitride coatings with good characteristics.

Depths of occurrence of NS for yttrium ions ($Y^{+}$) at an energy of 200 eV are: the minimum – $0 \ldots 1.23 \cdot 10^{-9}$ m, the maximum – $1.92 \cdot 10^{-9} \ldots 4.54 \cdot 10^{-9}$ m. At an energy of 2000 eV: the minimum – $6.53 \cdot 10^{-10} \ldots 5{,}79 \cdot 10^{-9}$ m. The maximum – $5.45 \cdot 10^{-9} \ldots 1.25 \cdot 10^{-8}$ m. At 20 keV: the minimum – $4.65 \cdot 10^{-9} \ldots 2.49 \cdot 10^{-8}$ m; The maximum is $1.55 \cdot 10^{-8} \ldots 3.55 \cdot 10^{-8}$ m.

The possibility of nitride formation taking into account the spatial nature of the action of nitrogen ions and basic metals was considered. A high-entropy coating with six metals can be realized in a VT2-MBC installation, where are four evaporators, two of which will contain cathodes of pure metals, and the other two will have two-component cathodes. So, for example, if one of the cathodes will be from the ZrHf20 (20 % Hf + 80 % Zr), In order to ensure the production of a highly entropic coating, it is necessary that hafnium be 7.5 %, and zirconium 30 % – the maximum possible amount of one component in the highly entropic coating. Then the calculations show that the remaining elements should be contained 15.6225 % in both single-component cathodes and in the two-component cathode. The calculations show that the operating time of the cathode with the material of the ZrHf20 should be four times less than the operating time of the remaining ones, which will ensure the required component ratio. The cathode must work periodic in order to ensure that the corresponding component ratios in the highly entropic nitride, carbide, boride and oxide coatings are obtained with the minimum amount of intermetallic compounds and amorphous phase.

Investigations of the action of ions B, O, N, Al, Ti, Cr with energy of 200, 2000 and 20000 eV on carbide CT T12A were carried out. As a result of the combined action of the considered types of ions, we can obtain a high-entropy coating. Taking into account the action of nitrogen ions, that is, selecting the appropriate ion energy, it is possible to obtain a high-entropy nitride, carbide, boride, sulfide, phosphide or oxide nanostructured coating.

By creating layers of high-entropy nitride, carbide, boride, sulfide, phosphide and oxide nanostructured coatings and selecting a sequence of layers (the first on the surface taking into account the adhesive interaction with the material being processed), we can design an effective cutting tool of high performance. The use of phosphorus and sulfur ions will allow to obtain almost the same volume of grains and the depth of their formation, so there is a real opportunity to create layers at the same time successfully working at sufficiently high temperatures (sulfides) with high resistance to abrasive wear (phosphides).

It is shown that in order to obtain effective high-entropy coatings, it is necessary to provide an appropriate space-time distribution law of the ion supply to the CT material by controlling the installation.

An algorithm for selecting technological modes for obtaining high-entropy nitride, carbide, boride and oxide nanocoating with alternating layers is proposed, taking into account the adhesive interaction of the surface layer with the processed material.

## References

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# PRINCIPLES FOR CREATING A NEW CLASS OF CUTTING TOOLS THAT ENSURE THE HIGHEST POSSIBLE EFFICIENCY OF FORMING AND PRODUCTIVITY OF MILLING

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Calculations were made for embodiments CT:

– VK10 (90 % WC and 10 % Co);

– a modified VK10 (79,7 % WC and 9,5 % Co1,3 % CrN; AlN 6,5 %, TiN 3 %) and VK20 (80 % WC and 20 % Co).

Calculated amounts of nanostructures ($V$), the minimum ($h_{min}$) and the maximum (hmax) of depth, as well as the grain size ($a$). The criterion for the formation of nanostructures in the volume considered the achievement of the desired temperature range (500…1500 K) implementing temperature increase rate of more than $10^7$ K/s. Were determined from the dependence of these quantities of energy ions (200, 2000, 20000 eV) by the action of one-, two- and triply charged ions. These values were calculated for the case of steps ions: boron, carbon, nitrogen, aluminum, vanadium, chromium, oxygen, iron, nickel, cobalt, yttrium, zirconium, molybdenum, hafnium, tantalum, tungsten and platinum. comparing these values were held to consider the three cutting tools.

In the case of the action of nitrogen ions (200 eV) to have a volume of 5.8 VK10$\cdot 10^{-27}$ m$^3$, $h_{min} = 7{,}97\cdot 10^{-10}$ m, $h_{max} = 3{,}02\cdot 10^{-9}$ m and a grain size is $2.23\cdot 10^{-9}$ m. To obtain the volume of 2.91 Modified VK10$\cdot 10^{-27}$ m$^3$, $h_{min} = 0$, $h_{max} = 2{,}88\cdot 10^{-9}$ m and a grain size is $1.77\cdot 10^{-9}$ m. If actions for nitrogen ions have VK20 volume $7.42\cdot 10^{-26}$ m$^3$, $h_{min} = 0$, $h_{max} = 8{,}46\cdot 10^{-9}$ m, and the grain size is $5.21\cdot 10^{-9}$ m.